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# THE HOLBROOK SPIRAL.

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# HOLBROOK'S SPIRAL.

If R be the radius of curvature at any point and L the distance of this point from the tangent point measured along the curve, and A a constant, then the definition of this curve is expressed

(1). $RL = A$

The following calculations are for a spiral whose degree increases one minute per foot - then

(2) $RL = A = \frac{180 \times 60 \times 60}{3.14159} = 34377.5$

(3) $R = \frac{34377.5}{L}$ Column headed R calculated from (3). Also, it follows that for the inclination of the curve at any point to the tangent we have

(4) $\Delta_1 = \frac{L^2}{2A} = 0.0000145445 L^2$ and representing $0.0000145445$ by A, we have

(5) $\Delta_1 = A_1 L^2$ In minutes (5) becomes

(6) $\Delta_1 = .005 L^2$. Column headed $\Delta_1$ calculated from (6).

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Let the curve be referred to rectangular axes with origin at P.C. and the tangent as axes of Y.

For convenience in laying out let us find X and Y in terms of L. To obtain this we have

(7) $\frac{dy}{dL} = \text{Cos. } \Delta_1 = \text{Cos. } A_1 L^2$ hence $Y = \int_0^L \text{Cos. } A_1 L^2 \, dL =$

$L - \frac{120^2 L^5}{1.2.3.4.5} + \frac{1680^4 L^9}{1.2.3.4.5.6.7.8.9} - \&c.$

Reducing we have:

(8) $Y = L - 0.0000000000000201557. L^5 + \&c.$

(9) $\frac{dx}{dL} = \text{Sin. } \Delta_1 = \text{Sin. } A_1 L^2$ hence $X = \int_0^L \text{Sin. } A_1 L^2 \, dL =$

$\frac{120 L^3}{1.2.3} - \frac{120^3 L^7}{1.2.3.4.5.6.7} + \&c.$ Reducing we have

(10) $X = 0.0000004848 L^3 + \&c.$

X and Y in the tables are calculated from (8) and (10).

If $X_0, Y_0$ be the coordinates of the point where the circle joining the spiral at a given point X, Y,

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becomes parallel to the tangent we have.

(11) $X_o = X - R \text{ vers} \sin \Delta$.

(12) $Y_o = Y - R \sin \Delta$. Columns headed $X_o$ and $Y_o$ are calculated from (11) and (12)

If D be the deflection necessary to be turned off from any point $Y_1$ on the tangent, tangent to any point $X, Y$, on the curve we have

(13) $\text{Tan. } D = \frac{X}{Y - Y_1}$

If we choose P.C. as a point from which to turn off deflections $Y_1 = 0$ and (13) becomes

(14) $\text{Tan. } D = \frac{X}{Y}$ Column headed D is calculated from (14) $D_1$ is calculated for $Y_1 = 200$.

Column C gives the length of chord corresponding to arc of 50 ft. for various degrees of curvature.

Let $\Delta$ = intersection angle, $T$ = length of tangent and $T_1$ = length of tangent of circular curve of some radius as middle part of

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curve and having intersection
$= \Delta$ or $T_1 = R \tan \frac{1}{2} \Delta$ Then we have

(15) $T = T_1 + X_0 \tan \frac{1}{2} \Delta + Y_0$ Substituting

(16) $T = (R + X_0) \tan \frac{1}{2} \Delta + Y_0$

Having found the length of the tangents by (16) and fixed the tangent points on the ground the Spiral ends may be run in by the deflection method using values taken from columns headed D or D, according as the transit is at P.C. or at 200ft. from it on the tangent towards the apex, or points may be located by ordinates found under head of X, or by any combination of these methods desired.

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## FIRST PROBLEM.

Given: Two tangents joined by a simple curve; required, the intersection angle being 27°15' to put in a 3° curve with Spirals having a rate of increase of 1° in 60'

By (16) $t = (r + x_0) \tan. \frac{1}{2}\Delta + y_0 = 554.99$ ft.

Having established the tangent points A A' figure 2 we set over each and turn off from the tangents the deflections found in the table under D. The instrument for the last deflection should read 0°36'15" The sum of the deflections for the circular arc

$$= \tfrac{1}{2}\Delta - \Delta_1 = 13°37'30" - 2°42'00" = 10°55'30"$$

And the length of the circular arc

$$= \frac{10°55'30"}{1°30'} \times 100 = 728.333 \text{ ft.}$$

Required: The intersection angle being 70°30', to put in a 2° curve, with Spirals having a rate of increase of 1° in 50 ft. The sum of the deflections for the circular arc

$$= \tfrac{1}{2}\Delta - \Delta_1 = 34°15'$$

And the length of the circular arc

$$= \frac{34°15'}{1°00'} \times 100 = 3425 \text{ ft.}$$

The back sight given, 100', being too short for accurately running in so long a curve, by the proceeding method, we may proceed as follows:

Establish the points E-E', figure 2 by BD = A Tan. $\frac{1}{2}\Delta$ = 2022.7 ft. and BE = $\frac{1}{2}$ = 9.146 ft.

As long a back sight as is desired can then be obtained by measuring off from a point down the tangent the distance 9.146 ft. The circular curve is then run in from the auxiliary tangents, the points F—F' being fixed by deflections for the chord

$$y_0 = 50 \text{ ft.}$$

The points A—A' being set by measuring back from B-B' the distance

$$y_0 = 50 \text{ ft.}$$

The instrument is set up at A or A', and the Spiral run in by deflections as before. Should it happen, as is sometimes the case in sharp curves, that the entire Spiral is not visible from A or A', the instrument may be moved two hundred feet along the tangent toward the apex, and further points established by turning off from the tangent deflections found in the table under D.

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# SECOND PROBLEM.

Given: Two tangents joined by a simple curve, to find a circular arc with spirals joining the same tangents, that will replace the simple curve on the same ground as nearly as may be.

It is evident that the new circular arc must be outside the old curve of the middle point H, since the application of spirals draws the curve inward the distance $X_o$; and that to retain the same tangents, the radius of the new curve must be less than that of the old.

Let FE be the curve to be replaced with a new curve and spirals.

If DE = $X_o$, and SC = the Spiral, then will SCD be the old curve with Spirals.

An inspection of figure 3 will show that SCD is inside the curve for its entire length. By trigonometry

$$EV = R \operatorname{exsec} \tfrac{1}{2}\Delta .$$

Now if we can find a curve with a radius R', such that R' $\operatorname{exsec} \tfrac{1}{2}\Delta$ will be such a quantity that when increased by $X_o$ the curve will still be outside the point E, we will have a curve which will nearly coincide with SFE, a little outside of E and a little inside of F. It is evident that R' is a little shorter than R and $x'_o$ for R' is a little longer than $x_o$ for R (see tables), $1\tfrac{1}{2}$ $x_o$ for R being always a little larger than $x'_o$ for R', the following formula may therefore be used in finding R'.

$$R' = \frac{R \operatorname{exsec} \tfrac{1}{2}\Delta - 1\tfrac{1}{2} x_o}{\operatorname{exsec} \tfrac{1}{2}\Delta} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (17)$$

Required: The intersection angle being 30°00', to replace a 6° curve with a new curve, with spirals having a rate of increase of 1° in 30', and replacing the simple curve on the same ground as nearly as may be.

$$\text{By (17)} \quad R' = \frac{R \operatorname{exsec} \tfrac{1}{2}\Delta - 1\tfrac{1}{2} x_o}{\operatorname{exsec} \tfrac{1}{2}\Delta}$$

$$= \frac{(954.93 \times .035276) - 2.11}{.035276}$$

$$= 897.95 \text{ ft} = R \text{ for a } 6°23' \text{ curve}$$

Deciding, therefore, upon the use of a 6°20', we have

$$\text{By (16)} \quad t = (R + X_o) \operatorname{Tan} \tfrac{1}{2}\Delta + y_o = 337.8 \text{ ft.}$$

A and A' are established, and the ordinary curve runs as in the first problem. The radii in the tables commonly in use, are calculated for chord lengths instead of arc lengths. The radii of these tables should therefore be always used, and when spirals are used on curves with very short radii, the deflections on the circular arc can be made for short chords of fifty or twenty-five feet, or the chord length calculated.

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## THIRD PROBLEM.

Given: Two tangents joined by a simple curve, to find a circular arc having a spiral at one end only, joining the same tangents. Because of the end of the curve being on a bridge, or other special feature in its location, it is sometimes desirable to retain one end of the new curve more nearly in its old position than is possible with the application of spirals to both ends. The end of the curve may then become a part of the circular arc, and a spiral applied to the free end only. The point A', figure 8, may be found by the formula:

$$t' = R \text{ Tan.} \tfrac{1}{2}\Delta + x_o (\text{Sec } 90° - \Delta) \quad \text{.....(18)}$$

The point A of the spiral may be found by the formula:

$$t'' = R \text{ Tan.} \tfrac{1}{2}\Delta + Y_o - x_o (\text{Tan. } 90° - \Delta) \quad \text{.....(19)}$$

Required: The intersection angle being 62° 26', to replace a 9°15' by a new curve, with a spiral having a rate of increase of one degree in twenty feet on one end only.

By (18) $t' = R \text{ Tan.} \tfrac{1}{2}\Delta + X_o (\text{Sec } 90° - \Delta)$
$= 619.41 \times .60602 + 2.32 \times 1.12807$
$= 377.93$ ft.

By (19) $t'' = R \text{ Tan.} \tfrac{1}{2}\Delta + Y_o - x_o (\text{Tan. } 90° - \Delta)$
$= 619.41 \times .60602 + 22.43 - 1.21$
$= 466.59$ ft.

Having established A and A', the new curve with spiral may then be run in as shown under the first problem.

## FOURTH PROBLEM

Given: Two tangents joined by a simple curve, to find a circular arc having an each end spirals differing in their rates of increase, joining the same tangents.

From an inspection of figure 9 it will be seen that

$$t' = R \text{ Tan.} \tfrac{1}{2}\Delta + Y_o + X'_o (\text{Sec } 90° - \Delta) - x_o (\text{Tan. } 90° - \Delta) \quad \text{...(20)}$$

$$t'' = R \text{ Tan.} \tfrac{1}{2}\Delta + Y_o' + x'_o (\text{Sec } 90° - \Delta) - x_o' (\text{Tan. } 90° - \Delta) \quad \text{....(21)}$$

Required: The intersection angle being 37°40', to replace a five degree curve by a new curve, having on one end a spiral increasing one degree in sixty feet, and on the other end a spiral increasing one degree in thirty feet.

For the end having a spiral increasing

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1° in 60ft.:
By (20) $t' = (1145.9 \times .34108) + 100.22 + (.82 \times 1.63648) - (3.29 \times 1.29541)$
$= 537.84$ ft.

For the end having a spiral increasing 1° in 30ft.
By (21) $t'' = (1145.9 \times .34108) + 75.00 + (3.29 \times 1.63648) - (.82 \times 1.29541)$
$= 470.16$ ft.

From the points thus found, run in the spirals and connect the same with a five degree curve, using deflections for fifty feet chords as in the first problem.

## FIFTH PROBLEM.

To connect two tangents by a reverse curve with spirals.

In the treatment of reverse curves, a formula which will enable us to determine the radius from a fixed length of tangent instead of determining the tangent from a given radius, will be very convenient. We may determine such equations as follows. It will be seen from the tables that

$2Y_0 = Y$ very nearly, hence $Y_0 = R \sin. \Lambda$ nearly.

The tables also show that $x_0$ is always small when compared with R, and may be discarded. (16) then becomes

$$R \tan. \tfrac{1}{2}\Lambda = t - R \sin. \Lambda$$
or $$\tan. \tfrac{1}{2}\Lambda = \frac{t}{R} - \frac{oo_1}{R}, \; l^2 \text{ nearly}$$

or $$\frac{1}{a} \tan. \tfrac{1}{2}\Lambda = \frac{tl}{oo_1} - l^2 \text{ nearly}$$

but $oo_1 = l$ [See lond 4]

hence $$l^2 - 2tl = -\frac{1}{a} \tan. \tfrac{1}{2}\Lambda \text{ nearly}$$

and $$l = t - \sqrt{t^2 - \frac{1}{a} \tan. \tfrac{1}{2}\Lambda} \quad \ldots\ldots\ldots\ldots (22)$$

A little study of figure five will show that the spirals joining the two branches must be carried to M, where the radii will be coincident, and this is a common point, viz: the point of reversal of curvature for two circular arcs joining the given tangents; find, therefore the point M, and the other two points, as for plain circular curves. Having determined these points, the radius, length of spirals, etc. may be found from (22). The two parts of the curve when thus located will be found to be considerably outside the two

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circular ares, joining the two tangents. The method does very well for new work, but no method of applying easement approaches has yet been devised which will create new curves with spirals nearly enough on the ground occupied by the old curves (if the old curves have short radii), to be of any practical use in maintenance of way work, because the application of spirals requires a lengthening of the tangents equal to nearly half the length of the spirals, and in reverse curves the length of the common tangents is fixed.

Required: The intersection angles being 40° and 60°, the common tangent nine hundred feet, there being used with one arm five hundred feet, with the other four hundred feet. The curve having tangents of five hundred feet to be fitted with spirals increasing one degree in thirty feet, and the curve having tangents of four hundred feet to be fitted with spirals increasing one degree in ten feet.

$$\text{By (22)} \quad t = 500 - \sqrt{250000 - 343775X.36397}$$
$$= 147 \text{ ft nearly}$$
$$t' = 400 - \sqrt{160000 - 114600X.57735}$$
$$= 94 \text{ ft nearly}$$

The tables show, by interpolation, that the radius for the first arm is 1146 feet, being that of a 5°00' curve, and that for the second arm is 611.85 ft., being that of a 9°24' curve.

The length of the spirals and the radii of the corresponding ares having been so determined, they may be run in as in the first problem.

## SIXTH PROBLEM

Given: Two tangents joined by a compound curve, to replace the same with two simple curves, joined to the tangents and to each other by spirals.

It is obvious that the joining of the two simple curves to the tangents presents no difficulties. Selecting for this purpose the branch with the shortest radius, its beginning point may be determined by the method given in the third problem, adding to the tangent of the circular curve the length:

$$Y_0 - X_0 \text{ Tan. } (90° - A') \ldots\ldots\ldots (23)$$

From an examination of figure seven, which shows in detail that part of figure six between B and S, it will appear that the com-

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men tangent to the two circular curves of their corresponding point will be moved toward the apex the distance CO = P, which is found from

$$\text{Tan. } j = \frac{y''_o - y'_o}{(R''-R') - (x''_o - x'_o)} \quad \ldots\ldots\ldots\ldots (24)$$

and that $p = R'' - R' - \frac{y''_o - y'_o}{\sin j} \quad \ldots\ldots\ldots\ldots (25)$

This quantity p so nearly equals $x_o$ for the length of the spiral joining the two circular arcs, that the latter may ordinarily be substituted for it. The length of the tangent of the branch with the longer radius will therefore be increased by

$$y''_o - x''_o \text{ Tan. } (90° - \Lambda'') - p \sec (90° - \Lambda'') \quad \ldots\ldots (26)$$

Observing now the new positions assumed by the circular arcs, they will be seen to overlap each other by a distance equal to

$$x'_o \sec (90° - \Lambda') + x''_o \sec (90° - \Lambda'') + p \text{ Tan. } (90° - \Lambda'') \quad \ldots\ldots (27)$$

Measuring back along the first branch from its end a distance

$$x'_o \sec (90° - \Lambda') \quad \ldots\ldots\ldots\ldots (28)$$

A point will be found opposite the middle point of the spiral connecting the two branches.

The length of the connecting spiral will be equal to so many feet as there are minutes in the difference in degree of the two branches of the curve, if a spiral increasing one degree in sixty feet be used; two-thirds, if one increasing one degree in forty feet; one-half if one increasing one degree in thirty-feet, etc.

The length of the connecting spiral and the position of a point opposite its center having been thus determined, its two ends may be fixed by measuring off on each branch from the determined point one-half its length. Having thus established ends, the spiral connecting them may be run in as follows:

From A turn off from the tangent to the circular arc at that point the angle $90° - \Lambda'$, as shown in figure six, and lay off that corresponding to R', from S turn off from the tangent to the circular arc at that point the angle $90° - \Lambda''$ and lay off $x''$ corresponding to R''. The two

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points found are on the tangent from which the connecting spiral springs. Its origin will be distant Y" for R" from the point located from S. From this last point run in the spiral connecting the two arcs from S to R, as in the first problem.

It will be seen that this solution permits of the use of spirals having different rates of increase for each end of the compound curve, and for the connecting spiral at the compounding point, and that it may also be applied to compound curves having more than one compounding point.

Required: The intersection angle between two tangents being 65°00' to connect the same by a compound curve — the one branch a five degree curve, intersection angle 50°00'; the other branch a three degree curve, intersection angle 15°00' — with spirals joining the tangents and connecting the circular arcs.

The tangent on the branch having the shorter radius is 956.74 feet. Using a spiral increasing one degree in forty feet, lengthens this by

$$(23) = Y'_o - X'_o \text{ Tan. } (90° - \Lambda')$$
$$= 99.98 - (1.45 \times .83910)$$
$$= 98.76$$

The tangent on the branch having the longer radius is 915.59 feet. Using a spiral increasing one degree in forty feet, and for the connecting spiral one increasing one degree in forty feet, lengthens this by (26)

$$(24) \text{ Tan. } j' = \frac{Y'_o - Y''_o}{(R'' - R') - (X'_o - X''_o)}$$

$$= \frac{99.98 - 90.00}{(1909.85 - 1145.91) - (1.45 - .707)}$$

$$= 0.01307$$
$$= 0°\,43'$$

$$(25) \; p = R'' - R' - \frac{Y'_o - Y''_o}{\sin j'}$$

$$= 1909.85 - 1145.91 - \frac{99.98 - 90.00}{0.01309}$$

$$= .153$$

$$(26) = Y''_o - X''_o \text{ Tan. } (90° - \Lambda'') - p \sec (90° - \Lambda'')$$
$$= 90.00 - (.707 \times 3.732\,05) - (.153 \times 3.86\,370)$$
$$= 86.77$$

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If $\rho$ is suggested, $\rho$ be taken as equal in value to the $x_0$ of the length of the connecting spiral, then would

$$(26) = y''_0 - x''_0 \text{ Tan. } (90^\circ - \Lambda'') - \rho \sec (90^\circ - \Lambda'')$$

$$= 90.00 - (.707 \times 3.73205) - (.146 \times 3.86370)$$

$$= 86.80$$

A difference of three-hundredths of a foot, about the width of a tack head. As this is much closer than the actual results to be obtained from the field work, the calculation of (24) and (25) may well be omitted

Having fixed the points on the tangents where the branches with spirals begin, run them in for their full length. The ends will lie on parallel tangents separated by $\rho$ feet, and will lap past each other the distance

$$(27) = x'_0 \sec (90^\circ - \Lambda') + x''_0 \sec (90^\circ - \Lambda'') + \rho \text{ Tan. } (90^\circ - \Lambda'')$$

$$= (1.45 \times 1.80541) + (.707 \times 3.86370) + (.146 \times 3.73205)$$

$$= 5.17$$

Measuring back from the end of the curve having the shorter radius a distance

$$(28) = x_0 \sec (90^\circ - \Lambda')$$

$$= (.146 \times 1.80541)$$

$$= 1.98$$

Fixes the point opposite the center of the connecting spiral, and measuring half the length of the connecting spiral, fifty feet, in both directions on the branches, establish the points R and S.

Setting up now at R, turn off from the tangent to the circular arc to that point the angle $90^\circ - \Lambda'' = 83^\circ 45'$ and measure along this line from R the distance $x'' = 209$ ft. for radius = 1145.91.

Setting up then at S, turn off from the tangent to the circular arc of that point the angle $90^\circ - \Lambda'' = 87^\circ 45'$ and measure along this line $x'' = 1.964$ ft. for radius = 1909.85. Two points found are in the line from which springs the spiral. Prolonging, therefore, this line, and measuring along it the distance $y'' = 147.954$, we obtain the origin of the connecting spiral, from which point the same may be run in, retaining for use, of course, only so much of it as lies between S and R.

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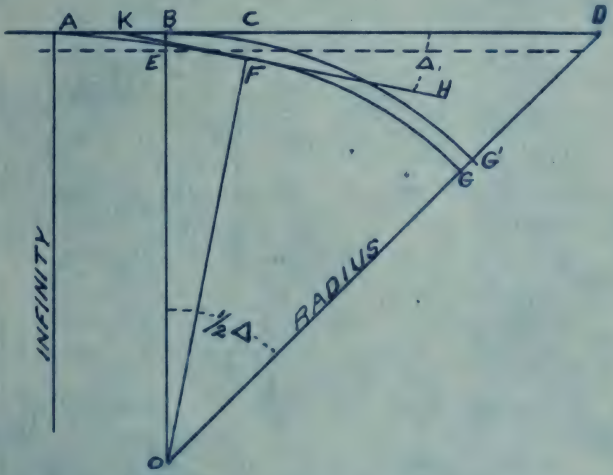
Figure 1.




BG' = original curve
AFG = spiral & arc
AD = tangent
AC = Y
CF = X
AB = Y.
BE = X.
BOG = ½ Δ
DXH = Δ'

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Figure 2.

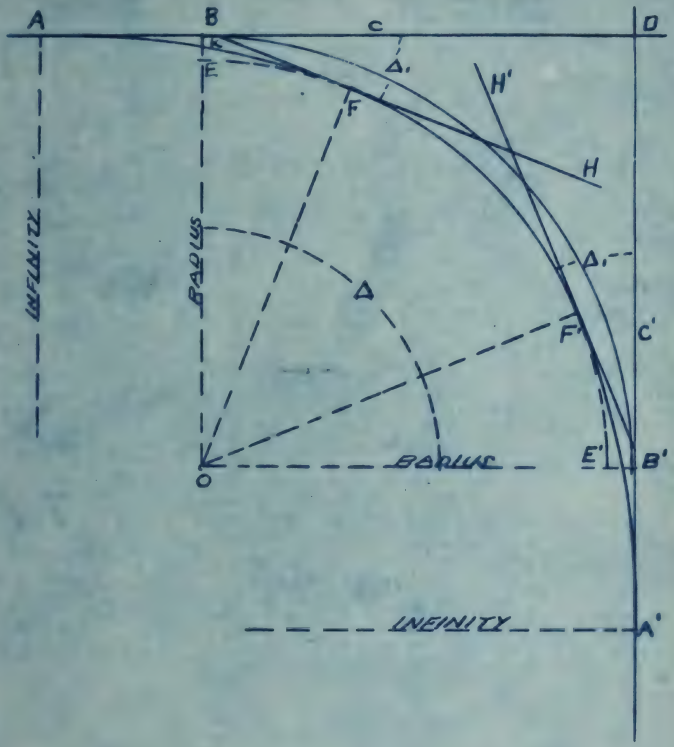

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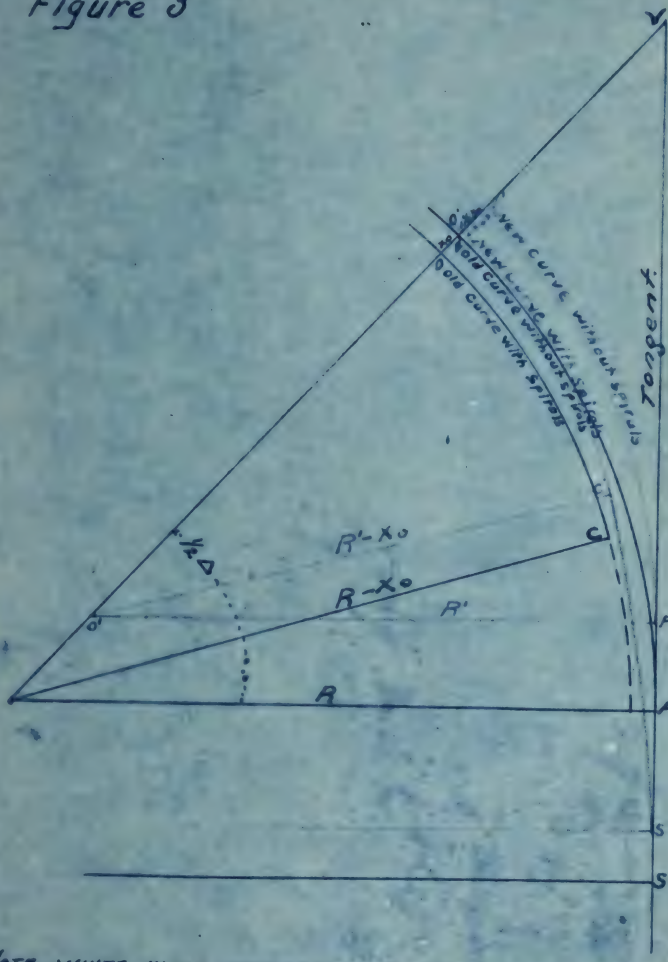
Figure 3




NOTE—WHITE LINES & LETTERS INDICATE FUNCTIONS OF OLD CURVE.
— RED LINES & LETTERS INDICATE FUNCTIONS OF NEW CURVE.

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Figure 4.

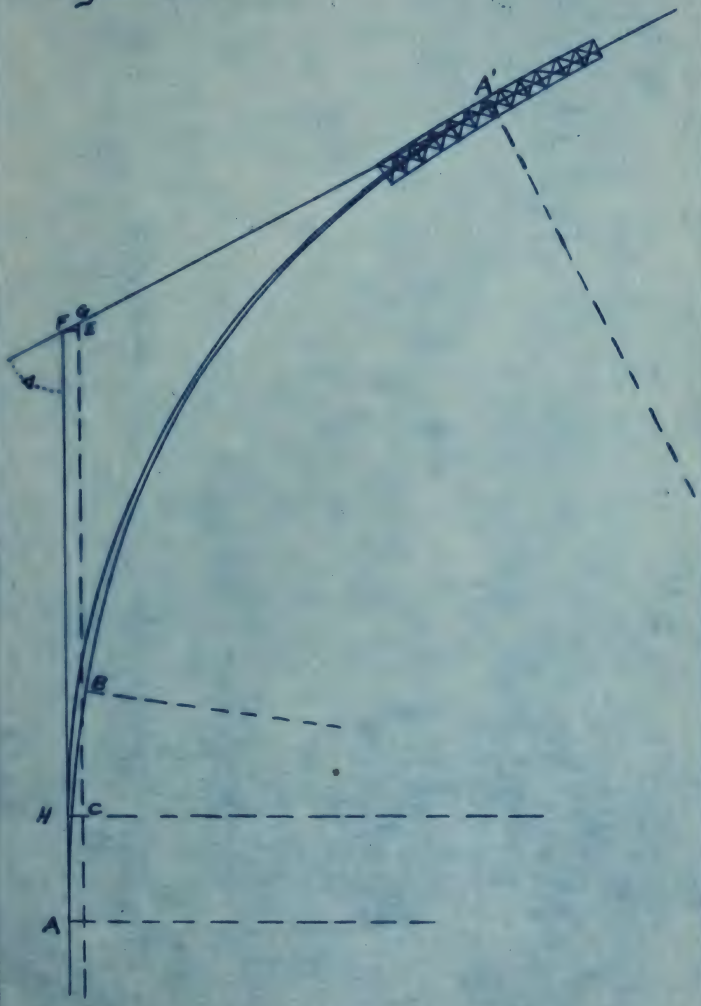

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Figure 4½

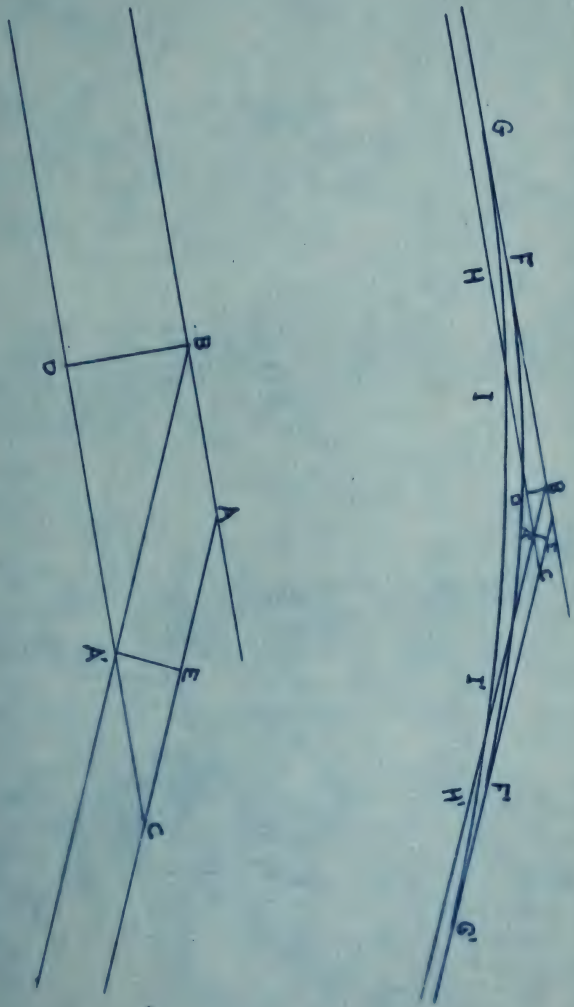

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Figure 5

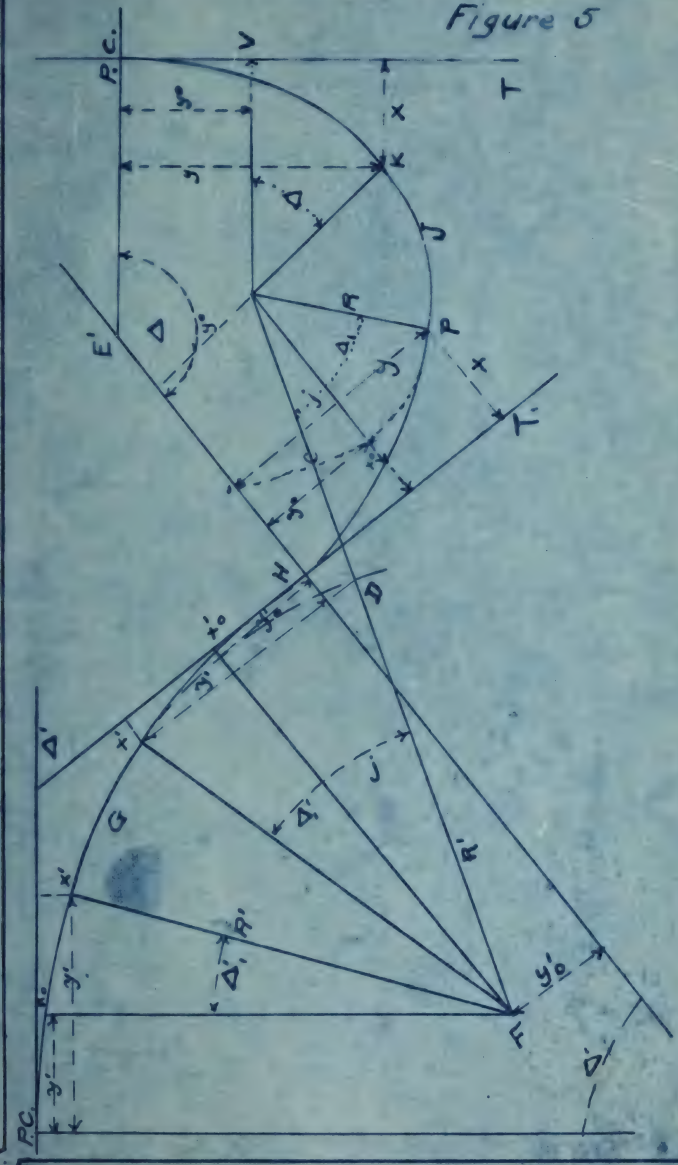

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Figure 6.

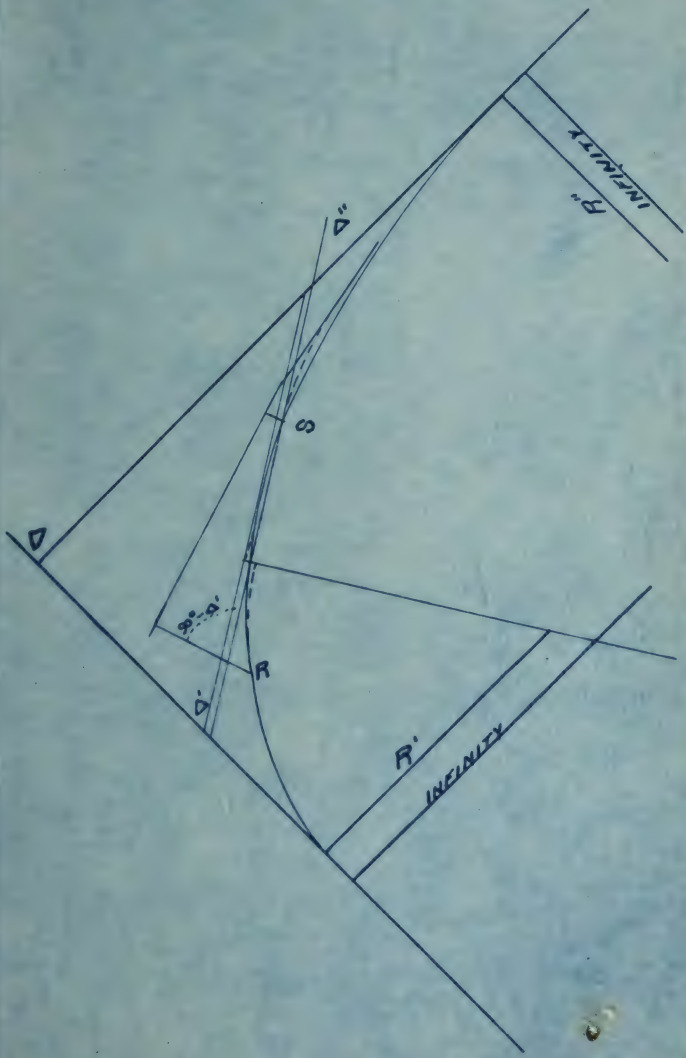

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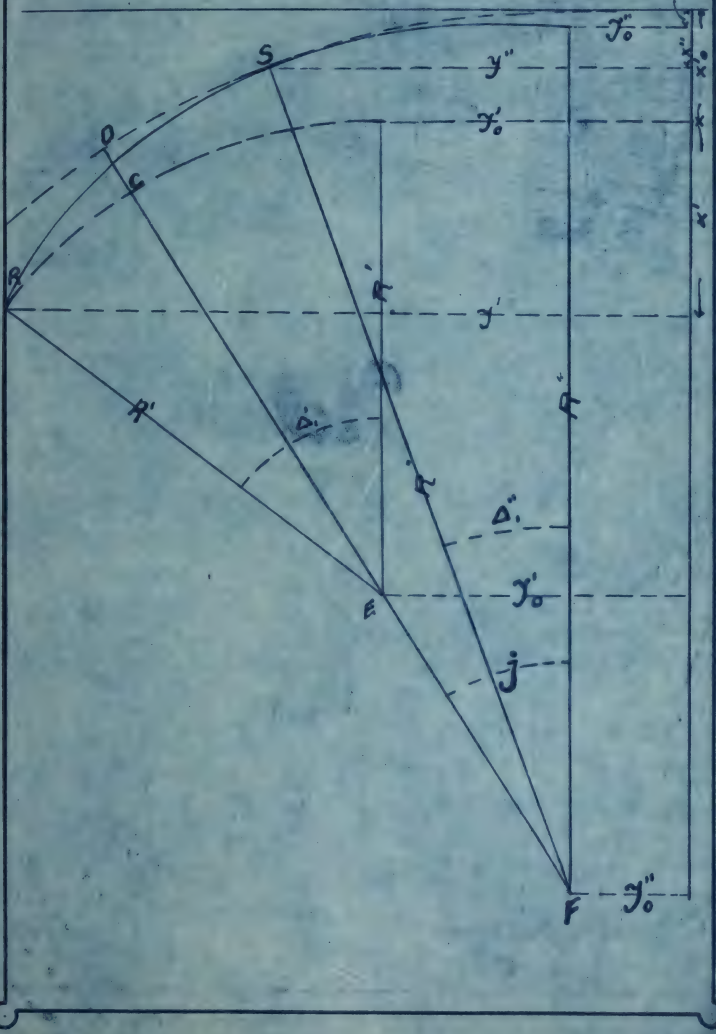
Figure 7.



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# Table of Spirals. Rate of Increase 1° in 10'

| L | Deg. | Radius. | Δ. | X | Y | $X_0$ | $Y_0$ | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0° 00' | Infinity. | 0° 00' 00" | .000 | 0.000 | .000 | 0.000 | 0° 00' 00" | |
| 10 | 1° 00' | 5729.58 | 03' | .003 | 10.000 | .001 | 5.000 | 0° 01' 01" | |
| 20 | 2° 00' | 2864.79 | 12' | .023 | 20.000 | .006 | 10.000 | 0° 03' 06" | |
| 30 | 3° 00' | 1909.86 | 27' | .079 | 30.000 | .021 | 15.000 | 0° 09' 02" | |
| 40 | 4° 00' | 1432.39 | 48' | .186 | 39.999 | .046 | 20.000 | 0° 16' 00" | |
| 50 | 5° 00' | 1145.91 | 1° 15' | .364 | 49.998 | .091 | 25.000 | 0° 25' 02" | |
| 60 | 6° 00' | 954.93 | 1° 48' | .628 | 59.994 | .157 | 29.999 | 0° 36' 00" | |
| 70 | 7° 00' | 818.51 | 2° 27' | .998 | 69.987 | .239 | 34.998 | 0° 49' 02" | |
| 80 | 8° 00' | 716.19 | 3° 12' | 1.489 | 79.975 | .372 | 39.996 | 1° 04' 00" | |
| 90 | 9° 00' | 636.62 | 4° 03' | 2.121 | 89.953 | .537 | 44.992 | 1° 21' 02" | |
| 100 | 10° 00' | 572.95 | 5° 00' | 2.909 | 99.924 | .729 | 49.988 | 1° 40' 02" | |
| 110 | 11° 00' | 520.87 | 6° 03' | 3.872 | 109.877 | .971 | 54.979 | 2° 01' 06" | |
| 120 | 12° 00' | 477.46 | 7° 12' | 5.027 | 119.811 | 1.263 | 59.969 | 2° 24' 10" | |
| 130 | 13° 00' | 440.73 | 8° 27' | 6.391 | 129.717 | 1.607 | 64.953 | 2° 49' 14" | |
| 140 | 14° 00' | 409.25 | 9° 48' | 7.982 | 139.590 | 2.011 | 69.932 | 3° 16' 20" | |
| 150 | 15° 00' | 381.98 | 11° 15' | 9.817 | 149.422 | 2.477 | 74.901 | 3° 43' 34" | |
| 160 | 16° 00' | 358.10 | 12° 48' | 11.915 | 159.202 | 3.016 | 79.865 | 4° 16' 48" | |
| 170 | 17° 00' | 337.04 | 14° 27' | 14.291 | 168.889 | 3.629 | 84.816 | 4° 50' 10" | |
| 180 | 18° 00' | 318.31 | 16° 12' | 16.964 | 178.561 | 4.325 | 89.755 | 5° 25' 36" | |
| 190 | 19° 00' | 301.51 | 18° 03' | 19.952 | 188.107 | 5.114 | 94.675 | 6° 03' 14" | |
| 200 | 20° 00' | 286.48 | 20° 00' | 23.271 | 197.563 | 5.995 | 99.581 | 6° 43' 02" | 95° 58' 36" |
| 210 | 21° 00' | 272.84 | 22° 03' | 26.939 | 206.890 | 6.983 | 104.462 | 7° 25' 02" | 75° 39' 12" |
| 220 | 22° 00' | 260.44 | 24° 12' | 30.974 | 216.076 | 8.087 | 109.316 | 8° 09' 28" | 62° 34' 15" |
| 230 | 23° 00' | 249.11 | 26° 27' | 35.392 | 224.999 | 9.317 | 114.101 | 8° 56' 20" | 54° 45' 45" |
| 240 | 24° 00' | 238.73 | 28° 48' | 40.212 | 233.837 | 10.683 | 118.827 | 9° 45' 28" | 49° 55' 40" |

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# Table of Spirals. Rate of Increase 1° in 10'

| L | Deg | Radius | Δ. | X | Y | X. | Y. | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 250 | 25° 00 | 229.118 | 31° 15' | 45.451 | 242.564 | 12.097 | 123.672 | 10° 36' 46" | 46° 52' 46" |
| 260 | 26° 00 | 220.368 | 33° 48' | 51.126 | 250.876 | 13.733 | 128.287 | 11° 29' 40" | 45° 08' 24" |
| 270 | 27° 00 | 212.206 | 36° 27' | 57.255 | 259.073 | 15.543 | 132.987 | 12° 27' 44" | 44° 06' 16" |
| 280 | 28° 00 | 204.628 | 39° 12' | 63.856 | 266.894 | 17.803 | 137.363 | 13° 27' 18" | 43° 40' 09" |
| 290 | 29° 00 | 197.571 | 42° 03' | 70.944 | 274.381 | 20.082 | 142.052 | 14° 29' 50" | 43° 48' 44" |
| 300 | 30° 00 | 190.986 | 45° 00' | 78.539 | 281.495 | 22.599 | 146.448 | 15° 35' 22" | 43° 56' 32" |
| 310 | 31° 00 | 184.825 | 48° 03' | 86.658 | 288.149 | 25.386 | 150.689 | 16° 44' 18" | 44° 32' 04" |
| 320 | 32° 00 | 179.049 | 51° 12 | 95.318 | 294.448 | 28.462 | 154.908 | 17° 56' 18" | 45° 16' 14" |
| 330 | 33° 00 | 173.624 | 54° 27' | 104.536 | 300.198 | 31.884 | 158.936 | 19° 11' 56" | 46° 13' 11" |
| 340 | 34° 00 | 168.517 | 57° 48' | 114.330 | 305.401 | 35.640 | 162.803 | 20° 31' 28" | 47° 19' 39" |
| 350 | 35° 00 | 163.702 | 61° 15 | 124.718 | 310.005 | 39.755 | 166.483 | 21° 54' 55" | 48° 35' 14" |
| 360 | 36° 00 | 159.155 | 64° 48 | 135.716 | 313.955 | 44.316 | 169.947 | 23° 22 42" | 49° 58' 50" |
| 370 | 37° 00 | 154.853 | 68° 27' | 147.343 | 317.181 | 49.370 | 173.153 | 24° 55 02" | 51° 44' 04" |
| 380 | 38° 00 | 150.778 | 72° 12' | 159.616 | 319.663 | 54.930 | 175.103 | 26° 32 44" | 53° 08' 26" |
| 390 | 39° 00 | 146 912 | 76° 03' | 172.551 | 321.295 | 61.056 | 178.716 | 28° 14' 20" | 54° 54' 20" |
| 400 | 40° 00 | 143 239 | 80° 00' | 186.168 | 322.022 | 67.807 | 180.957 | 30° 01' 57" | 56° 45' 27" |
| 410 | 41° 00 | 139.654 | 84° 03' | 200.482 | 321.776 | 75.306 | 182.874 | 31° 55' 37" | 58 44' 30" |
| 420 | 42° 00 | 136.419 | 88° 12' | 215.572 | 320.479 | 83.579 | 184.127 | 33° 56' 50" | 60° 47' 36" |
| 430 | 43° 00 | 133.246 | 92° 27' | 231.276 | 318.053 | 103.726 | 184.927 | 36° 01' 37" | 62° 58' 30" |
| 440 | 44° 00 | 130.218 | 96° 48 | 247.789 | 314.416 | 130.993 | 185.123 | 38° 15' 08" | 65° 12' 50" |
| 450 | 45° 00 | 127.324 | 101° 15' | 265.071 | 309.482 | 161.314 | 184.605 | 40° 34' 58" | 67° 33' 30" |
| 460 | 46° 00 | 124.556 | 105° 48' | 283.138 | 303.159 | 193.431 | 183.309 | 43° 02' 35" | 69° 58' 54" |
| 470 | 47° 00 | 121.906 | 110° 27' | 302.007 | 295.354 | 227.294 | 181.131 | 45° 38' 12" | 72° 28' 30" |
| 480 | 48° 00 | 119.366 | 115° 12' | 321.698 | 285.967 | 263.874 | 177.962 | 48° 21' 53" | 75° 02' 17" |

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# Table of Spirals. Rate of Increase 1° in 20'

| L | Deg | Radius | Δ. | X | Y. | X. | Y. | D | D |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0° 00' | Infinity | 0° 00' 00" | .000 | .000 | .000 | 0.000 | 0° 00' 00" | |
| 10 | 0° 30' | 11459.16 | 0° 01' 30" | .001 | 10.000 | .000 | 5.000 | 0° 00' 38" | |
| 20 | 1° 00' | 5729.58 | 0° 06' 00" | .012 | 20.000 | .003 | 10.000 | 0° 02' 04" | |
| 30 | 1° 30' | 3819.72 | 0° 13' 30" | .037 | 30.000 | .009 | 15.000 | 0° 04' 27" | |
| 40 | 2° 00' | 2864.79 | 0° 24' 00" | .093 | 40.000 | .023 | 20.000 | 0° 07' 57" | |
| 50 | 2° 30' | 2291.83 | 0° 37' 30" | .182 | 49.999 | .046 | 25.000 | 0° 12' 30" | |
| 60 | 3° 00' | 1909.86 | 0° 54' 00" | .314 | 59.998 | .078 | 30.000 | 0° 17' 57" | |
| 70 | 3° 30' | 1635.02 | 1° 13' 30" | .499 | 69.997 | .125 | 35.000 | 0° 24' 29" | |
| 80 | 4° 00' | 1432.39 | 1° 36' 00" | .745 | 79.994 | .187 | 39.999 | 0° 32' 01" | |
| 90 | 4° 30' | 1273.24 | 2° 01' 30" | 1.060 | 89.989 | .265 | 44.998 | 0° 40' 29" | |
| 100 | 5° 00' | 1145.91 | 2° 30' 00" | 1.454 | 99.981 | .363 | 49.997 | 0° 49' 40" | |
| 110 | 5° 30' | 1041.74 | 3° 01' 30" | 1.936 | 109.969 | .484 | 54.995 | 1° 00' 30" | |
| 120 | 6° 00' | 954.93 | 3° 36' 00" | 2.513 | 119.953 | .629 | 59.992 | 1° 12' 01" | |
| 130 | 6° 30' | 881.47 | 4° 13' 30" | 3.195 | 129.939 | .799 | 64.988 | 1° 24' 30" | |
| 140 | 7° 00' | 818.51 | 4° 54' 00" | 3.991 | 139.897 | 1.000 | 69.982 | 1° 38' 03" | |
| 150 | 7° 30' | 763.94 | 5° 37' 30" | 4.909 | 149.856 | 1.230 | 74.977 | 1° 52' 36" | |
| 160 | 8° 00' | 71619 | 6° 24' 00" | 5.957 | 159.800 | 1.494 | 79.968 | 2° 08' 19" | |
| 170 | 8° 30' | 674.07 | 7° 13' 30" | 7.146 | 169.730 | 1.794 | 84.953 | 2° 24' 38" | |
| 180 | 9° 00' | 636.62 | 8° 06' 00" | 8.482 | 179.640 | 2.131 | 89.939 | 2° 42' 12" | |
| 190 | 9° 30' | 603.11 | 9° 01' 30" | 9.976 | 199527 | 2.509 | 94.926 | 3° 00' 46" | |
| 200 | 10° 00' | 572.95 | 10° 00' 00" | 11.636 | 199.391 | 2.932 | 99.899 | 3° 20' 23" | 92° 40' 4 |
| 210 | 10° 30' | 545.67 | 11° 01' 30" | 13.470 | 209.229 | 3.399 | 104.877 | 3° 41' 01" | 55° 23' 5 |
| 220 | 11° 00' | 520.87 | 12° 06' 00" | 15.487 | 219.019 | 3.915 | 109.835 | 4° 02' 34" | 34° 09' 1 |
| 230 | 11° 30' | 498.22 | 13° 13' 30" | 17.696 | 228774 | 4.485 | 114.791 | 4° 25' 32" | 21° 35' 3 |
| 240 | 12° 00' | 477.46 | 14° 24' 00" | 20.106 | 238.484 | 5.112 | 119.745 | 4° 49' 09" | 13° 35' 0 |

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# Table of Spirals. Rate of Increase 1° in 20'

| L | Deg. | Radius. | Δ. | X | Y | $X_o$ | $Y_o$ | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 250 | 12° 30' | 458.37 | 15° 37' 30" | 22.726 | 248.141 | 5.799 | 124.684 | 5° 13' 54" | 25° 16' 14" |
| 260 | 13° 00' | 440.73 | 16° 54' 00" | 25.563 | 257.719 | 6.549 | 129.598 | 5° 39' 52" | 23° 53' 17" |
| 270 | 13° 30' | 424.42 | 18° 13' 30" | 28.628 | 267.268 | 7.365 | 134.531 | 6° 06' 50" | 23° 03' 12" |
| 280 | 14° 00' | 409.25 | 19° 36' 00" | 31.928 | 276.723 | 8.250 | 139.439 | 6° 34' 54" | 22° 35' 38" |
| 290 | 14° 30' | 395.15 | 21° 01' 30" | 35.473 | 286.095 | 9.207 | 144.325 | 7° 03' 54" | 22° 20' 12" |
| 300 | 15° 00' | 381.98 | 22° 30' 00" | 39.270 | 295.373 | 10.235 | 149.196 | 7° 34' 24" | 22° 22' 46" |
| 310 | 15° 30' | 369.65 | 24° 01' 30" | 43.330 | 304.536 | 11.339 | 154.038 | 8° 05' 58" | 22° 30' 32" |
| 320 | 16° 00' | 358.10 | 25° 36' 00" | 47.659 | 313.579 | 12.539 | 158.849 | 8° 38' 31" | 22° 45' 47" |
| 330 | 16° 30' | 347.25 | 27° 13' 30" | 52.269 | 322.549 | 13.799 | 163.698 | 9° 12' 18" | 23° 03' 32" |
| 340 | 17° 00' | 337.04 | 28° 54' 00" | 57.166 | 331.359 | 15.193 | 168.473 | 9° 47' 19" | 23° 24' 28" |
| 350 | 17° 30' | 327.42 | 30° 37' 30" | 62.360 | 340.000 | 16.691 | 173.207 | 10° 23' 36" | 23° 56' 32" |
| 360 | 18° 00' | 318.31 | 32° 24' 00" | 67.859 | 348.487 | 18.307 | 177.928 | 11° 01' 08" | 24° 31' 43" |
| 370 | 18° 30' | 309.71 | 34° 13' 30" | 73.672 | 356.793 | 20.041 | 182.598 | 11° 40' 00" | 25° 08' 01" |
| 380 | 19° 00' | 301.51 | 36° 06' 00" | 79.809 | 364.914 | 21.916 | 187.265 | 12° 20' 21" | 25° 49' 27" |
| 390 | 19° 30' | 293.82 | 38° 01' 30" | 86.277 | 372.821 | 23.911 | 191.866 | 13° 01' 49" | 26° 31' 46" |
| 400 | 20° 00' | 286.48 | 40° 00' 00" | 93.085 | 380.502 | 26.061 | 196.356 | 13° 44' 50" | 27° 16' 49" |
| 410 | 20° 30' | 279.49 | 42° 01' 30" | 100.242 | 387.941 | 28.372 | 200.835 | 14° 29' 18" | 28° 04' 27" |
| 420 | 21° 00' | 272.84 | 44° 06' 00" | 107.757 | 395.116 | 30.860 | 205.243 | 15° 15' 11" | 28° 54' 57" |
| 430 | 21° 30' | 266.49 | 46° 13' 30" | 115.639 | 402.020 | 33.514 | 209.598 | 16° 02' 55" | 29° 47' 12" |
| 440 | 22° 00' | 260.44 | 48° 24' 00" | 123.896 | 408.600 | 36.369 | 213.843 | 16° 52' 01" | 30° 42' 07" |
| 450 | 22° 30' | 254.62 | 50° 37' 30" | 132.537 | 414.866 | 39 4[illegible] | 8.031 | 17° 42' 19" | 31° 40' 01" |
| 460 | 23° 00' | 249.11 | 52° 54' 00" | 141.570 | 420.785 | 42 8[illegible] | 222.099 | 18° 35' 18" | 32° 40' 06" |
| 470 | 23° 30' | 243.81 | 55° 13' 30" | 151.005 | 426.333 | [illegible] | 226.068 | 19° 30' 16" | 33° 42' 37" |
| 480 | 24° 00' | 238.73 | 57° 36' 00" | 160.851 | 431.[illegible] | [illegible] | 229.919 | 20° 26' 46" | 34° 47' 39" |

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# Table of Spirals. Rate of Increase 1° in 30'

| L | Deg. | Radius | Δ. | X | Y | $X_0$ | $Y_0$ | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0° 00' | 00000.00 | 0° 00' 00" | .000 | 0.00 | .00 | 0.00 | 0° 00' 00" | |
| 10 | 0° 20' | 17188.75 | 0° 01' 00" | .002 | 10.00 | .00 | 5.00 | 0° 00' 45" | |
| 20 | 0° 40' | 8594.32 | 0° 04' 00" | .008 | 20.00 | .00 | 10.00 | 0° 01' 30" | |
| 30 | 1° 00' | 5729.55 | 0° 09' 00" | .026 | 30.00 | .01 | 15.00 | 0° 03' 00" | |
| 40 | 1° 20' | 4297.15 | 0° 16' 00" | .062 | 40.00 | .02 | 20.00 | 0° 04' 40" | |
| 50 | 1° 40' | 3477.75 | 0° 25' 00" | .120 | 50.00 | .03 | 25.00 | 0° 08' 00" | |
| 60 | 2° 00' | 2864.77 | 0° 36' 00" | .210 | 60.00 | .05 | 30.00 | 0° 12' 00" | |
| 70 | 2° 20' | 2455.52 | 0° 49' 00" | .330 | 70.00 | .08 | 35.00 | 0° 16' 20" | |
| 80 | 2° 40' | 2148.57 | 1° 04' 00" | .500 | 80.00 | .12 | 40.00 | 0° 21' 30" | |
| 90 | 3° 00' | 1909.85 | 1° 21' 00" | .710 | 89.99 | .18 | 45.00 | 0° 27' 00" | |
| 100 | 3° 20' | 1718.86 | 1° 40' 00" | .970 | 99.99 | .24 | 50.00 | 0° 33' 20" | |
| 110 | 3° 40' | 1562.60 | 2° 01' 00" | 1.290 | 109.99 | .32 | 55.00 | 0° 40' 20" | |
| 120 | 4° 00' | 1432.39 | 2° 24' 00" | 1.670 | 119.98 | .42 | 60.00 | 0° 47' 50" | |
| 130 | 4° 20' | 1322.10 | 2° 49' 00" | 2.130 | 129.97 | .53 | 65.00 | 0° 56' 20" | |
| 140 | 4° 40' | 1227.76 | 3° 16' 00" | 2.650 | 139.95 | .66 | 70.00 | 1° 05' 10" | |
| 150 | 5° 00' | 1145.91 | 3° 45' 00" | 3.270 | 149.93 | .82 | 75.00 | 1° 15' 00" | |
| 160 | 5° 20' | 1074.28 | 4° 16' 00" | 3.980 | 159.92 | .99 | 79.99 | 1° 25' 30" | |
| 170 | 5° 40' | 1011.09 | 4° 49' 00" | 4.760 | 169.88 | 1.19 | 84.99 | 1° 36' 20" | |
| 180 | 6° 00' | 954.93 | 5° 24' 00" | 5.650 | 179.84 | 1.41 | 89.98 | 1° 48' 00" | |
| 190 | 6° 20' | 904.66 | 6° 01' 00" | 6.650 | 189.80 | 1.66 | 94.97 | 2° 00' 20" | |
| 200 | 6° 40' | 859.43 | 6° 40' 00" | 7.750 | 199.72 | 1.94 | 99.95 | 2° 13' 20" | 92° 04' 15" |
| 210 | 7° 00' | 818.57 | 7° 21' 00" | 8.970 | 209.64 | 2.24 | 104.93 | 2° 27' 00" | 42° 56' 20" |
| 220 | 7° 20' | 781.30 | 8° 04' 00" | 10.320 | 219.54 | 2.57 | 109.92 | 2° 41' 30" | 27° 50' 26" |
| 230 | 7° 40' | 747.30 | 8° 49' 00" | 11.780 | 229.44 | 2.95 | 114.90 | 2° 56' 20" | 21° 48' 30" |
| 240 | 8° 00' | 716.20 | 9° 36' 00" | 13.464 | 239.32 | 3.43 | 119.88 | 3° 12' 00" | 18° 54' 08" |

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# Table of Spirals. Rate of Increase 1° in 30'

| L | Deg | Radius | Δ | X | Y | $X_o$ | $Y_o$ | D | $D_1$ |
|---|---|---|---|---|---|---|---|---|---|
| 250 | 8° 20' | 687.77 | 10° 25' 00" | 15.150 | 249.17 | 3.82 | 124.81 | 3° 28' 45" | 17° 07' 30" |
| 260 | 8° 40' | 661.10 | 11° 16' 00" | 17.041 | 258.99 | 4.30 | 129.83 | 3° 45' 50" | 16° 06' 48" |
| 270 | 9° 00' | 636.62 | 12° 09' 00" | 19.085 | 268.79 | 4.83 | 134.80 | 4° 03' 40" | 15° 30' 25" |
| 280 | 9° 20' | 613.85 | 13° 04' 00" | 21.285 | 278.54 | 5.39 | 139.76 | 4° 22' 10" | 15° 09' 50" |
| 290 | 9° 40' | 592.71 | 14° 01' 00" | 23.648 | 288.26 | 6.00 | 144.70 | 4° 41' 25" | 15° 00' 00" |
| 300 | 10° 00' | 572.95 | 15° 00' 00" | 26.179 | 297.95 | 6.66 | 149.66 | 5° 01' 15" | 14° 56' 54" |
| 310 | 10° 20' | 554.47 | 16° 01' 00" | 28.885 | 307.57 | 7.36 | 154.58 | 5° 21' 50" | 15° 02' 55" |
| 320 | 10° 40' | 537.14 | 17° 04' 00" | 31.771 | 317.17 | 8.12 | 159.53 | 5° 43' 15" | 15° 10' 16" |
| 330 | 11° 00' | 520.87 | 18° 09' 00" | 34.844 | 326.69 | 8.93 | 164.43 | 6° 05' 20" | 15° 22' 42" |
| 340 | 11° 20' | 505.55 | 19° 16' 00" | 38.109 | 336.16 | 9.79 | 169.34 | 6° 28' 00" | 15° 38' 12" |
| 350 | 11° 40' | 491.11 | 20° 25' 00" | 41.571 | 345.56 | 10.71 | 174.24 | 6° 51' 35" | 15° 56' 20" |
| 360 | 12° 00' | 477.46 | 21° 36' 00" | 45.238 | 354.88 | 11.70 | 179.72 | 7° 15' 50" | 16° 16' 58" |
| 370 | 12° 20' | 464.56 | 22° 49' 00" | 49.113 | 364.13 | 12.76 | 183.98 | 7° 40' 50" | 16° 39' 50" |
| 380 | 12° 40' | 452.33 | 24° 04' 00" | 53.203 | 373.30 | 13.80 | 188.84 | 8° 06' 40" | 17° 04' 00" |
| 390 | 13° 00' | 440.73 | 25° 21' 00" | 57.516 | 382.37 | 15.07 | 193.67 | 8° 32' 35" | 17° 31' 02" |
| 400 | 13° 20' | 429.71 | 26° 40' 00" | 62.054 | 391.34 | 16.35 | 198.49 | 9° 00' 35" | 17° 58' 07" |
| 410 | 13° 40' | 419.23 | 28° 01' 00" | 66.805 | 400.20 | 17.68 | 203.28 | 9° 28' 35" | 18° 27' 12" |
| 420 | 14° 00' | 409.25 | 29° 24' 00" | 71.846 | 408.94 | 19.14 | 208.04 | 9° 57' 50" | 18° 58' 40" |
| 430 | 14° 20' | 399.73 | 30° 49' 00" | 77.090 | 417.56 | 20.65 | 212.78 | 10° 27' 35" | 19° 30' 55" |
| 440 | 14° 40' | 390.65 | 32° 16' 00" | 82.594 | 426.04 | 22.27 | 217.49 | 10° 58' 15" | 20° 04' 22" |
| 450 | 15° 00' | 381.98 | 33° 45' 00" | 88.355 | 434.39 | 23.98 | 222.17 | 11° 29' 50" | 20° 39' 20" |
| 460 | 15° 20' | 373.66 | 35° 16' 00" | 94.376 | 442.57 | 25.80 | 226.83 | 12° 02' 15" | 21° 15' 40" |
| 470 | 15° 40' | 365.71 | 36° 49' 00" | 100.667 | 450.59 | 27.73 | 231.43 | 12° 35' 40" | 21° 53' 15" |
| 480 | 16° 00' | 358.10 | 38° 24' 00" | 107.230 | 458.44 | 29.67 | 236.01 | 13° 09' 50" | 22° 32' 03" |

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# Table of Spirals. Rate of Increase 1° in 40'.

| L | Deg | Radius | Δ. | X | Y | $X_o$ | $Y_o$ | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0° 00' | Infinity. | 0° 00' 00" | 0.0 | 0.00 | 0.00 | 0.00 | 0° 00' 00" | |
| 10 | 0° 15' | 22918.31 | 0° 00' 45" | 0.0 | 10.00 | 0.00 | 5.00 | 0° 00' 22" | |
| 20 | 0° 30' | 11459.15 | 0° 03' 00" | 0.01 | 20.00 | 0.00 | 10.00 | 0° 01' 30" | |
| 30 | 0° 45' | 7639.42 | 0° 06' 45" | 0.02 | 30.00 | 0.00 | 15.00 | 0° 02' 15" | |
| 40 | 1° 00' | 5729.58 | 0° 12' 00" | 0.05 | 40.00 | 0.01 | 20.00 | 0° 03' 45" | |
| 50 | 1° 15' | 4583.66 | 0° 18' 45" | 0.09 | 50.00 | 0.02 | 25.00 | 0° 06' 15" | |
| 60 | 1° 30' | 3910.72 | 0° 27' 00" | 0.15 | 60.00 | 0.04 | 30.00 | 0° 09' 00" | |
| 70 | 1° 45' | 3274.04 | 0° 36' 45" | 0.25 | 70.00 | 0.06 | 35.00 | 0° 12' 15" | |
| 80 | 2° 00' | 2864.79 | 0° 48' 00" | 0.37 | 80.00 | 0.09 | 40.00 | 0° 16' 00" | |
| 90 | 2° 15' | 2546.48 | 1° 00' 45" | 0.53 | 90.00 | 0.13 | 45.00 | 0° 20' 15" | |
| 100 | 2° 30' | 2291.83 | 1° 15' 00" | 0.73 | 100.00 | 0.18 | 50.00 | 0° 25' 00" | |
| 110 | 2° 45' | 2083.48 | 1° 30' 45" | 0.97 | 110.00 | 0.24 | 55.00 | 0° 30' 15" | |
| 120 | 3° 00' | 1909.86 | 1° 48' 00" | 1.25 | 119.99 | 0.31 | 60.00 | 0° 36' 00" | |
| 130 | 3° 15' | 1762.95 | 2° 06' 45" | 1.60 | 129.98 | 0.40 | 65.00 | 0° 42' 15" | |
| 140 | 3° 30' | 1637.02 | 2° 27' 00" | 1.99 | 139.97 | 0.49 | 70.00 | 0° 49' 00" | |
| 150 | 3° 45' | 1527.88 | 2° 48' 45" | 2.45 | 149.96 | 0.61 | 75.00 | 0° 56' 15" | |
| 160 | 4° 00' | 1432.39 | 3° 12' 00" | 2.98 | 159.95 | 0.74 | 80.00 | 1° 04' 00" | |
| 170 | 4° 15' | 1348.14 | 3° 36' 45" | 3.57 | 169.93 | 0.89 | 85.00 | 1° 12' 15" | |
| 180 | 4° 30' | 1273.24 | 4° 03' 00" | 4.24 | 179.91 | 1.06 | 90.00 | 1° 21' 00" | |
| 190 | 4° 45' | 1206.23 | 4° 30' 45" | 4.99 | 189.89 | 1.24 | 94.99 | 1° 30' 15" | |
| 200 | 5° 00' | 1145.91 | 5° 00' 00" | 5.82 | 199.84 | 1.45 | 99.98 | 1° 40' 15" | 91° 25' 32" |
| 210 | 5° 15' | 1091.35 | 5° 30' 45" | 6.73 | 209.80 | 1.68 | 104.97 | 1° 50' 15" | 33° 35' 43" |
| 220 | 5° 30' | 1041.74 | 6° 03' 00" | 7.74 | 219.75 | 1.93 | 109.96 | 2° 01' 00" | 21° 23' 59" |
| 230 | 5° 45' | 996.44 | 6° 30' 45" | 8.84 | 229.69 | 2.22 | 114.84 | 2° 12' 15" | 16° 34' 49" |
| 240 | 6° 00' | 954.93 | 7° 12' 00" | 10.05 | 239.62 | 2.51 | 119.93 | 2° 24' 00" | 14° 14' 00" |

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# Table of Spirals. Rate of Increase 1° in 40'

| L | Deg. | Radius | Δ. | X | Y | X₀ | Y₀ | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 250 | 6° 15' | 916.73 | 7° 48' 45" | 11.37 | 249.53 | 2.86 | 124.92 | 2° 36' 30" | 12° 55' 41" |
| 260 | 6° 30' | 881.47 | 8° 27' 00" | 12.77 | 259.44 | 3.19 | 129.91 | 2° 49' 20" | 12° 07' 30" |
| 270 | 6° 45' | 848.83 | 9° 6' 45" | 14.30 | 269.33 | 3.57 | 134.89 | 3° 02' 20" | 11° 40' 16" |
| 280 | 7° 00' | 818.51 | 9° 48' 00" | 15.95 | 279.19 | 4.00 | 139.87 | 3° 16' 10" | 11° 23' 15" |
| 290 | 7° 15' | 790.29 | 10° 30' 45" | 17.72 | 289.03 | 4.45 | 144.84 | 3° 30' 30" | 11° 15' 24" |
| 300 | 7° 30' | 763.94 | 11° 15' 00" | 19.60 | 298.85 | 4.93 | 149.81 | 3° 45' 10" | 11° 12' 54" |
| 310 | 7° 45' | 739.30 | 12° 00' 45" | 21.63 | 308.65 | 5.44 | 154.78 | 4° 00' 20" | 11° 15' 34" |
| 320 | 8° 00' | 716.20 | 12° 48' 00" | 23.79 | 318.40 | 5.99 | 159.74 | 4° 16' 20" | 11° 21' 38" |
| 330 | 8° 15' | 694.49 | 13° 36' 45" | 26.09 | 328.13 | 6.58 | 164.70 | 4° 32' 40" | 11° 30' 36" |
| 340 | 8° 30' | 674.07 | 14° 27' 00" | 28.53 | 337.84 | 7.21 | 169.65 | 4° 49' 40" | 11° 41' 36" |
| 350 | 8° 45' | 654.81 | 15° 18' 45" | 31.12 | 347.50 | 7.88 | 174.60 | 5° 07' 00" | 11° 54' 45" |
| 360 | 9° 00' | 636.62 | 16° 12' 00" | 33.89 | 357.12 | 8.61 | 179.54 | 5° 25' 20" | 12° 10' 18" |
| 370 | 9° 15' | 619.41 | 17° 06' 45" | 36.82 | 366.70 | 9.39 | 184.48 | 5° 44' 02" | 12° 27' 18" |
| 380 | 9° 30' | 603.11 | 18° 03' 00" | 39.89 | 376.23 | 10.21 | 189.36 | 6° 03' 09" | 12° 45' 14" |
| 390 | 9° 45' | 587.64 | 19° 00' 45" | 43.12 | 385.70 | 11.06 | 194.27 | 6° 22' 43" | 13° 04' 21" |
| 400 | 10° 00' | 572.95 | 20° 00' 00" | 46.52 | 395.12 | 11.97 | 199.16 | 6° 42' 43" | 13° 24' 41" |
| 410 | 10° 15' | 558.98 | 21° 00' 45" | 50.11 | 404.48 | 12.94 | 204.05 | 7° 03' 44" | 13° 46' 10" |
| 420 | 10° 30' | 545.67 | 22° 03' 00" | 53.86 | 413.79 | 13.45 | 208.93 | 7° 24' 58" | 14° 08' 24" |
| 430 | 10° 45' | 532.98 | 23° 06' 45" | 57.80 | 422.99 | 15.02 | 213.79 | 7° 46' 50" | 14° 31' 52" |
| 440 | 11° 00' | 520.87 | 24° 12' 00" | 61 93 | 432.15 | 16.16 | 218.65 | 8° 09' 20" | 14° 56' 12" |
| 450 | 11° 15' | 509.29 | 25° 18' 45" | 66.25 | 441.21 | 17.35 | 223.50 | 8° 32' 20" | 15° 21' 25" |
| 460 | 11° 30' | 498.22 | 26° 27' 00" | 70.76 | 450.20 | 18.61 | 228.29 | 8° 55' 56" | 15° 47' 45" |
| 470 | 11° 45' | 487.62 | 27° 36' 45" | 75.48 | 459.08 | 19.94 | 233.08 | 9° 20' 12" | 16° 14' 35" |
| 480 | 12° 00' | 477.46 | 28° 48' 00" | 80.40 | 467.77 | 21.34 | 237.75 | 9° 45' 10" | 16° 42' 45" |

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# Table of Spirals. Rate of Increase 1° in 50'

| L | Deg | Radius. | Δ. | X | Y | $X_o$ | $Y_o$ | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 00' | Infinity. | 0° 00' 00" | .000 | 00.000 | 0.000 | 0.000 | 0° 00' 00" | |
| 10 | 12' | 28647.90 | 0° 00' 36" | .001 | 10.000 | 0.000 | 5.000 | 0° 00' 22" | |
| 20 | 24' | 14323.95 | 0° 02' 24" | .004 | 20.000 | 0.000 | 10.000 | 0° 00' 42" | |
| 30 | 36' | 9549.30 | 0° 05' 24" | .016 | 30.000 | 0.004 | 15.000 | 0° 01' 50" | |
| 40 | 48' | 7161.97 | 0° 09' 36" | .037 | 40.000 | 0.010 | 20.000 | 0° 03' 10" | |
| 50 | 1° 00' | 5729.58 | 0° 15' 00" | .073 | 50.000 | 0.019 | 25.000 | 0° 05' 01" | |
| 60 | 1° 12' | 4774.65 | 0° 21' 36" | .126 | 60.000 | 0.030 | 30.000 | 0° 07' 13" | |
| 70 | 1° 24' | 4092.55 | 0° 29' 24" | .200 | 69.999 | 0.049 | 35.000 | 0° 09' 48" | |
| 80 | 1° 36' | 3580.98 | 0° 38' 24" | .298 | 79.998 | 0.075 | 40.000 | 0° 12' 46" | |
| 90 | 1° 48' | 3183.10 | 0° 48' 36" | .424 | 89.996 | 0.106 | 45.000 | 0° 16' 12" | |
| 100 | 2° 00' | 2864.79 | 1° 00' 00" | .582 | 99.994 | 0.146 | 50.000 | 0° 20' 12" | |
| 110 | 2° 12' | 2604.35 | 1° 12' 36" | .775 | 109.990 | 0.195 | 54.996 | 0° 24' 13" | |
| 120 | 2° 24' | 2387.32 | 1° 26' 24" | 1.001 | 119.985 | 0.245 | 59.992 | 0° 28' 39" | |
| 130 | 2° 36' | 2203.68 | 1° 41' 24" | 1.278 | 129.977 | 0.319 | 64.989 | 0° 33' 46" | |
| 140 | 2° 48' | 2046.27 | 1° 57' 36" | 1.597 | 139.967 | 0.401 | 69.984 | 0° 39' 13" | |
| 150 | 3° 00' | 1909.86 | 2° 15' 00" | 1.964 | 149.954 | 0.491 | 74.973 | 0° 45' 02" | |
| 160 | 3° 12' | 1790.49 | 2° 33' 36" | 2.384 | 159.936 | 0.598 | 79.964 | 0° 51' 14" | |
| 170 | 3° 24' | 1685.17 | 2° 53' 24" | 2.859 | 169.911 | 0.720 | 84.949 | 0° 57' 49" | |
| 180 | 3° 36' | 1591.55 | 3° 14' 24" | 3.394 | 179.885 | 0.851 | 89.934 | 1° 03' 54" | |
| 190 | 3° 48' | 1507.75 | 3° 36' 36" | 3.991 | 189.849 | 0.999 | 94.916 | 1° 12' 15" | |
| 200 | 4° 00' | 1432.39 | 4° 00' 00" | 4.655 | 199.805 | 1.166 | 99.886 | 1° 20' 04" | 92° 23' 16" |
| 210 | 4° 12' | 1364.18 | 4° 24' 36" | 5.389 | 209.753 | 1.350 | 104.859 | 1° 28' 17" | 28° 55' 21" |
| 220 | 4° 24' | 1302.17 | 4° 50' 24" | 6.196 | 219.686 | 1.540 | 109.818 | 1° 36' 17" | 17° 28' 15" |
| 230 | 4° 36' | 1245.56 | 5° 17' 24" | 7.080 | 229.608 | 1.775 | 114.772 | 1° 45' 58" | 13° 26' 54" |
| 240 | 4° 48' | 1193.66 | 5° 45' 36" | 8.044 | 239.515 | 1.917 | 119.718 | 1° 55' 24" | 11° 30' 23" |

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# Table of Spirals. Rate of Increase 1° in 50'

| L | Deg. | Radius | Δ. | X | Y | X₀ | Y₀ | D | D₁ |
|---|---|---|---|---|---|---|---|---|---|
| 250 | 5° 00' | 1145.91 | 6° 15' 00" | 9.092 | 249.405 | 2.281 | 124.653 | 2° 05' 15" | 10° 25' 39" |
| 260 | 5° 12' | 1101.84 | 6° 45' 36" | 10.228 | 259.270 | 2.578 | 129.572 | 2° 15' 34" | 9° 47' 27" |
| 270 | 5° 24' | 1061.03 | 7° 17' 24" | 11.454 | 269.125 | 2.878 | 134.491 | 2° 26' 13" | 9° 24' 30" |
| 280 | 5° 36' | 1023.13 | 7° 50' 24" | 12.774 | 278.950 | 3.210 | 139.388 | 2° 37' 19" | 9° 11' 27" |
| 290 | 5° 48' | 987.86 | 8° 24' 36" | 14.192 | 288.750 | 3.519 | 144.270 | 2° 48' 48" | 9° 05' 43" |
| 300 | 6° 00' | 954.93 | 9° 00' 00" | 15.712 | 298.519 | 3.955 | 149.135 | 3° 00' 45" | 9° 04' 14" |
| 310 | 6° 12' | 924.12 | 9° 36' 36" | 17.336 | 308.251 | 4.368 | 153.977 | 3° 13' 02" | 9° 06' 24" |
| 320 | 6° 24' | 895.24 | 10° 14' 24" | 19.068 | 317.955 | 4.810 | 158.806 | 3° 25' 54" | 9° 11' 25" |
| 330 | 6° 36' | 868.12 | 10° 53' 24" | 20.912 | 327.615 | 5.279 | 163.605 | 3° 39' 12" | 9° 18' 48" |
| 340 | 6° 48' | 842.58 | 11° 33' 36" | 22.872 | 337.231 | 5.781 | 168.382 | 3° 52' 51" | 9° 28' 09" |
| 350 | 7° 00' | 818.51 | 12° 15' 00" | 24.950 | 346.799 | 6.313 | 173.130 | 4° 06' 47" | 9° 38 59" |
| 360 | 7° 12' | 795.63 | 12° 57' 36" | 27.150 | 356.315 | 6.882 | 177.876 | 4° 21' 26" | 9° 51' 02" |
| 370 | 7° 24' | 774.26 | 13° 41' 24" | 29.476 | 365.772 | 7.480 | 182.529 | 4° 36' 26" | 10° 04' 55" |
| 380 | 7° 36' | 753.89 | 14° 26' 24" | 31.931 | 375.170 | 8.114 | 187.175 | 4° 51' 54" | 10° 19' 50" |
| 390 | 7° 48' | 734.56 | 15° 12' 36" | 34.519 | 384.500 | 8.788 | 191.782 | 5° 07' 47" | 10° 35' 50" |
| 400 | 8° 00' | 716.19 | 16° 00' 00" | 37.243 | 393.757 | 9.499 | 195.350 | 5° 24' 11" | 10° 52' 50" |
| 410 | 8° 12' | 698.72 | 16° 48' 36" | 40.107 | 402.939 | 10.250 | 200.866 | 5° 41' 03" | 11° 10' 45" |
| 420 | 8° 24' | 682.09 | 17° 38' 24" | 43.113 | 412.034 | 11.041 | 205.335 | 5° 58' 23" | 11° 29' 35" |
| 430 | 8° 36' | 666.22 | 18° 29' 24" | 46.266 | 421.040 | 11.876 | 209.754 | 6° 16' 14" | 11° 49' 19" |
| 440 | 8° 48' | 651.09 | 19° 21' 36" | 49.570 | 429.948 | 12.760 | 214.107 | 6° 34' 36" | 12° 09' 35" |
| 450 | 9° 00' | 636.62 | 20° 15' 00" | 53.027 | 438.753 | 13.678 | 218.411 | 6° 53' 28" | 12° 31' 19" |
| 460 | 9° 12' | 622.78 | 21° 09' 36" | 56.641 | 447.447 | 14.651 | 222.636 | 7° 12' 53" | 12° 53' 35" |
| 470 | 9° 24' | 609.53 | 22° 05' 24" | 60.416 | 456.022 | 15.673 | 226.778 | 7° 32' 48" | 13° 16' 42" |
| 480 | 9° 36' | 596.83 | 23° 02' 24" | 64.355 | 464.470 | 16.667 | 230.806 | 7° 53' 18" | 13° 40' 35" |

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# Table of Spirals. Rate of Increase 1° in 60'

| L | Deg | Radius | Δ | x | Y | $X_o$ | $Y_o$ | D | $D_1$ |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0° | Infinity. | 0 | 0.000 | 0.000 | .000 | .00 | 00' | |
| 10 | 10' | 34377.50 | 30" | 0.000 | 10.000 | .000 | 5.00 | 20' | |
| 20 | 20' | 17188.75 | 2 | .004 | 20.000 | .001 | 10.00 | 40" | |
| 30 | 30' | 11459.20 | 4 | .013 | 30.000 | .013 | 15.00 | 1° 10' | |
| 40 | 40' | 8594.52 | 8 | 0.031 | 40.000 | .008 | 20.00 | 2° 10' | |
| 50 | 50' | 6875.46 | 12 | 0.061 | 50.000 | .013 | 25.00 | 3° 30' | |
| 60 | 1° 00' | 5729.55 | 18 | 0.105 | 60.000 | .027 | 30.00 | 5° 10' | |
| 70 | 1° 10' | 4911.17 | 24 | 0.166 | 70.000 | .044 | 35.00 | 7° 10" | |
| 80 | 1° 20' | 4297.15 | 32 | 0.248 | 79.999 | .076 | 40.00 | 9° 30" | |
| 90 | 1° 30' | 3819.70 | 40 | 0.354 | 89.999 | .087 | 45.00 | 12° 10 | |
| 100 | 1° 40 | 3437.75 | 50' 30" | 0.485 | 99.999 | .107 | 50.00 | 15° 10 | |
| 110 | 1° 50 | 3125.21 | 1° 00' 30" | 0.645 | 109.999 | .145 | 55.00 | 18° 30 | |
| 120 | 2° 00 | 2864.77 | 1° 12 | 0.836 | 119.999 | .206 | 60.00 | 22° 10" | |
| 130 | 2° 10' | 2644.41 | 1° 24 | 1.065 | 129.999 | .272 | 65.00 | 26° 10" | |
| 140 | 2° 20' | 2455.52 | 1° 38 | 1.330 | 139.999 | .323 | 70.00 | 30° 30" | |
| 150 | 2° 30' | 2291.82 | 1° 53' 30 | 1.636 | 149.998 | .410 | 75.00 | 35° 10" | |
| 160 | 2° 40 | 2148.57 | 2° 08' 30" | 1.980 | 159.999 | .503 | 80.00 | 40° 10" | |
| 170 | 2° 50 | 2022.19 | 2° 24' 30" | 2.382 | 169.991 | .592 | 85.00 | 45° 30" | |
| 180 | 3° 00' | 1909.85 | 2° 42' 00" | 2.827 | 179.962 | .709 | 90.00 | 51° 10" | |
| 190 | 3° 10' | 1809.33 | 3° 00' 30" | 3.325 | 189.950 | .828 | 95.00 | 57° 10" | |
| 200 | 3° 20' | 1718.86 | 3° 20' 00" | 3.878 | 199.936 | .973 | 100.00 | 1° 03' 30" | 90° 00' 00" |
| 210 | 3° 30' | 1637.01 | 3° 40' 30" | 4.490 | 209.918 | 1.118 | 105.00 | 1° 10' 10" | 24° 23' 00" |
| 220 | 3° 40' | 1562.00 | 4° 02' 00" | 5.162 | 219.896 | 1.287 | 109.99 | 1° 17' 10" | 14° 46' 00" |
| 230 | 3° 50 | 1491.66 | 24 30" | 5.899 | 229.870 | 1.475 | 114.99 | 1° 24' 30" | 11° 11' 00" |
| 240 | 4° 00' | 1432.39 | 4° 48 00" | 6.702 | 239.849 | 1.674 | 119.98 | 1° 33' 10" | 9° 33' 00" |

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# Table of Spirals. Rate of Increase 1° in 60'

| L | Deg | Radius | Δ | X | Y | $X_0$ | $Y_0$ | D | D |
|---|---|---|---|---|---|---|---|---|---|
| 250 | 4° 10' | 1375.09 | 5° 12' 50" | 7.580 | 249.804 | 1.841 | 124.97 | 1° 40' | 8° 39' 00" |
| 260 | 4° 20' | 1322.10 | 5° 38' 00" | 8.521 | 259.758 | 2.135 | 129.97 | 1° 48' 30" | 7° 57' 20" |
| 270 | 4° 30' | 1273.20 | 6° 04' 05" | 9.542 | 269.710 | 2.412 | 134.97 | 1° 56' 10" | 7° 47' 10" |
| 280 | 4° 40' | 1227.76 | 6° 32' 00" | 10.642 | 279.653 | 2.674 | 139.96 | 2° 05' 10" | 7° 40' 30" |
| 290 | 4° 50' | 1185.40 | 7° 00' 30" | 11.824 | 289.586 | 2.971 | 144.95 | 2° 14' 30" | 7° 30' 50" |
| 300 | 5° 00' | 1145.91 | 7° 30' 00" | 13.090 | 299.510 | 3.290 | 149.92 | 2° 24' 10" | 7° 29' 00" |
| 310 | 5° 10' | 1108.95 | 8° 00' 30" | 14.443 | 309.421 | 3.635 | 154.91 | 2° 34' 10" | 7° 30' 40" |
| 320 | 5° 20' | 1074.28 | 8° 32' 00" | 15.886 | 319.324 | 3.994 | 159.89 | 2° 44' 30" | 7° 34' 20" |
| 330 | 5° 30' | 1041.73 | 9° 04' 30" | 17.451 | 329.211 | 4.403 | 164.88 | 2° 55' 10" | 7° 40' 10" |
| 340 | 5° 40' | 1011.09 | 9° 38' 00" | 19.055 | 339.084 | 4.940 | 169.87 | 3° 06' 10" | 7° 47' 20" |
| 350 | 5° 50' | 982.21 | 10° 12' 30" | 20.786 | 348.941 | 5.238 | 174.86 | 3° 17' 30" | 7° 55' 05" |
| 360 | 6° 00' | 954.93 | 10° 48' 00" | 22.619 | 358.781 | 5.707 | 179.84 | 3° 28' 10" | 8° 05' 20" |
| 370 | 6° 10' | 929.11 | 11° 24' 30" | 24.557 | 368.602 | 6.198 | 184.82 | 3° 40' 10" | 8° 15' 50" |
| 380 | 6° 20' | 904.66 | 12° 02' 00" | 26.602 | 378.402 | 6.727 | 189.79 | 3° 52' 30" | 8° 27' 30" |
| 390 | 6° 30' | 881.50 | 12° 40' 30" | 28.758 | 388.181 | 7.276 | 194.76 | 4° 05' 10" | 8° 39' 50" |
| 400 | 6° 40' | 859.43 | 13° 20' 00" | 31.027 | 397.936 | 7.857 | 199.73 | 4° 18' 10" | 8° 52' 50" |
| 410 | 6° 50' | 838.47 | 14° 00' 30" | 33.413 | 407.665 | 8.485 | 204.70 | 4° 31' 30" | 9° 06' 40" |
| 420 | 7° 00' | 818.57 | 14° 42' 00" | 35.918 | 417.366 | 9.126 | 209.64 | 4° 55' 10" | 9° 20' 40" |
| 430 | 7° 10' | 799.47 | 15° 24' 30" | 38.545 | 427.037 | 9.812 | 214.61 | 5° 09' 10" | 9° 35' 30" |
| 440 | 7° 20' | 781.30 | 16° 08' 00" | 41.297 | 436.676 | 10.529 | 219.57 | 5° 23' 30" | 9° 51' 00" |
| 450 | 7° 30' | 763.90 | 16° 52' 30" | 44.177 | 446.281 | 11.283 | 224.52 | 5° 38' 10" | 10° 07' 00" |
| 460 | 7° 40' | 747.30 | 17° 38' 00" | 47.188 | 455.849 | 12.072 | 229.47 | 5° 53' 10" | 10° 23' 20" |
| 470 | 7° 50' | 731.40 | 18° 24' 30" | 50.333 | 465.377 | 12.907 | 234.39 | 6° 08' 30" | 10° 40' 10" |
| 480 | 8° 00' | 716.20 | 19° 12' 00" | 53.615 | 474.864 | 13.780 | 239.32 | 6° 24' 10" | 10° 57' 40" |

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# Table of Spirals - Rate of Increase 1° in 80'.

| L | Deg | Radius | Δ. | X | Y | $X_o$ | $Y_o$ | D | $D_1$ |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | Infinity. | 00" | 0 | 0 | 0 | 0 | | 0' 00" |
| 10 | 7 30 | 4583.56 | 22½ | 0 | 10.00 | 0 | 5.0 | | 0' 00" |
| 20 | 15 00 | 2291.83 | 1' 30" | .00291 | 20.00 | .0007 | 10.0 | | 0' 30" |
| 30 | 22 30 | 1527.89 | 3' 22" | .00982 | 30.00 | .0022 | 15.0 | | 1' 08" |
| 40 | 30 00 | 1145.16 | 6' 00" | .02327 | 40.00 | .0061 | 20.0 | | 2' 00" |
| 50 | 37 30 | 916.73 | 9' 22½ | .04545 | 50.00 | .0115 | 25.0 | | 3' 08" |
| 60 | 45 00 | 763.94 | 13' 30" | .07854 | 60.00 | .0197 | 30.0 | | 4' 31" |
| 70 | 52 30 | 654809 | 18' 22½ | .12472 | 70.00 | .0311 | 35.0 | | 6' 07" |
| 80 | 1° 00 00 | 572.958 | 24' 00" | .18617 | 80.00 | .0464 | 40.0 | | 7' 59" |
| 90 | 1° 07 30 | 509.296 | 30' 22½ | .26507 | 90.00 | .0660 | 45.0 | | 10' 07" |
| 100 | 1° 15 00 | 458366 | 37' 30" | .36361 | 99.9999 | .0909 | 50.0 | | 12' 30" |
| 110 | 1° 22 30 | 416.697 | 45' 22½ | .48396 | 109.9981 | .121 | 55.0 | | 15' 08" |
| 120 | 1° 30 00 | 381.972 | 54' 00" | .62832 | 119.9970 | .157 | 60.0 | | 18' 00" |
| 130 | 1° 37 30 | 352.590 | 1° 03' 22½ | .79885 | 129.9956 | .200 | 65.0 | | 21' 01" |
| 140 | 1° 45 00 | 327.405 | 1° 13' 30" | .99775 | 139.9936 | .250 | 70.0 | | 24' 30" |
| 150 | 1° 52 30 | 305.377 | 1° 24' 22½ | 1.22718 | 149.9910 | .307 | 75.0 | | 28' 07" |
| 160 | 2° 00 00 | 286.479 | 1° 36' 00" | 1.48935 | 159.9875 | .375 | 80.0 | | 32' 02" |
| 170 | 2° 07 30 | 269.627 | 1° 48' 22½ | 1.78642 | 169.9831 | .447 | 85.0 | | 36' 08" |
| 180 | 2° 15 00 | 254.648 | 2° 01' 30" | 2.12057 | 179.9775 | .531 | 90.0 | | 40' 27" |
| 190 | 2° 22 30 | 241.245 | 2° 15' 22½ | 2.49390 | 189.9705 | .624 | 95.0 | | 45' 08" |
| 200 | 2° 30 00 | 229.183 | 2° 30' 00" | 2.90888 | 199.9619 | .728 | 100.00 | | 50' 00" |
| 210 | 2° 37 30 | 218.270 | 2° 45' 22½ | 3.36739 | 209.9514 | .842 | 105.00 | | 55' 08" |
| 220 | 2° 45 00 | 208.348 | 3° 01' 30" | 3.87172 | 219.9387 | .969 | 110.00 | 1° | 00' 30" |
| 230 | 2° 52 30 | 199.290 | 3° 18' 22½ | 4.42484 | 229.9234 | 1.107 | 115.00 | 1° | 06' 08" |
| 240 | 3° 00 00 | 190.986 | 3° 36' 00" | 5.02654 | 239.9052 | 1.259 | 119.98 | 1° | 12' 00" |

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# Table of Spirals Rate of Increase 1 in 50'

| L | Deg | Radius | Δ. ' | X | Y | $X_1$ | $Y_1$ | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 280 | 3° 03' 30" | 1839.47 | 3° 54' 22" | 279.8141 | 19.50938 | 1.422 | 124.98 | | 1° 10' 12" |
| 290 | 3° 10' 30" | 1762.95 | 4° 13' 36" | 289.8051 | 21.85586 | 1.600 | 129.97 | | 1° 24' 32" |
| 300 | 3° 17' 30" | 1697.65 | 4° 33' 22" | 299.7893 | 24.29293 | 1.793 | 134.97 | | 1° 37' 09" |
| 310 | 3° 24' 30" | 1637.02 | 4° 54' 00" | 309.7652 | 26.79952 | 2.000 | 139.96 | | 1° 48' 04" |
| 320 | 3° 31' 30" | 1580.57 | 5° 15' 22" | 319.8408 | 29.37584 | 2.222 | 144.96 | | 1° 55' 11" |
| 330 | 3° 38' 30" | 1527.88 | 5° 37' 30" | 329.8174 | 32.02209 | 2.460 | 149.95 | | 1° 52' 34" |
| 340 | 3° 45' 30" | 1478.60 | 6° 00' 22" | 339.8325 | 34.73839 | 2.716 | 154.94 | | 2° 00' 13" |
| 350 | 3° 52' 30" | 1432.29 | 6° 24' 00" | 349.8467 | 37.52487 | 2.988 | 159.93 | | 2° 08' 06" |
| 360 | 3° 59' 30" | 1388.99 | 6° 48' 22" | 359.8674 | 40.38165 | 3.279 | 164.93 | | 2° 16' 15" |
| 370 | 4° 06' 30" | 1348.14 | 7° 13' 30" | 369.8933 | 43.30879 | 3.587 | 169.91 | | 2° 24' 39" |
| 380 | 4° 13' 30" | 1309.62 | 7° 39' 22" | 379.9248 | 46.30650 | 3.913 | 174.90 | | 2° 33' 17" |
| 390 | 4° 20' 30" | 1273.24 | 8° 05' 00" | 389.9605 | 49.37477 | 4.263 | 179.89 | | 2° 42' 04" |
| 400 | 4° 27' 30" | 1238.83 | 8° 31' 22" | 399.9999 | 52.51369 | 4.631 | 184.86 | | 2° 51' 28" |
| 410 | 4° 34' 30" | 1206.23 | 9° 01' 30" | 410.0430 | 55.72332 | 5.019 | 189.86 | | 3° 00' 47" |
| 420 | 4° 41' 30" | 1175.30 | 9° 30' 22" | 420.0898 | 59.00366 | 5.430 | 194.85 | | 3° 10' 28" |
| 430 | 4° 48' 30" | 1145.91 | 10° 00' 00" | 430.1404 | 62.35478 | 5.862 | 199.80 | | 3° 20' 24" |

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# Table of Spirals. Rate of Increase 1° in 100'

| L | Deg | Radius | Δ. | X | Y | X. | Y. | D | D. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 00' | Infinity. | 0° 00' 00" | .000 | 00.000 | .000 | 0.000 | 0° 00' 00" | |
| 10 | 06' | 57295.80 | 0° 00' 18" | .000 | 10.000 | .000 | 5.000 | 0° 00' 00" | |
| 20 | 12' | 28647.90 | 0° 01' 12" | .002 | 20.000 | .000 | 10.000 | 0° 00' 15" | |
| 30 | 18' | 19098.60 | 0° 02' 42" | .008 | 30.000 | .002 | 15.000 | 0° 01' 00" | |
| 40 | 24' | 14323.95 | 0° 04' 48" | .019 | 40.000 | .005 | 20.000 | 0° 01' 40" | |
| 50 | 30' | 11459.16 | 0° 07' 30" | .036 | 50.000 | .010 | 25.000 | 0° 02' 30" | |
| 60 | 36' | 9549.30 | 0° 10' 48" | .063 | 60.000 | .017 | 30.000 | 0° 03' 35" | |
| 70 | 42' | 8185.11 | 0° 14' 42" | .100 | 70.000 | .026 | 35.000 | 0° 04' 55" | |
| 80 | 48' | 7161.97 | 0° 19' 12" | .149 | 80.000 | .037 | 40.000 | 0° 06' 25" | |
| 90 | 54' | 6366.20 | 0° 24' 18" | .212 | 90.000 | .052 | 45.000 | 0° 08' 05" | |
| 100 | 1° 00' | 5729.58 | 0° 30' 00" | .290 | 100.000 | .072 | 50.000 | 0° 10' 00" | |
| 110 | 1° 06' | 5208.70 | 0° 36' 18" | .387 | 110.000 | .096 | 55.000 | 0° 12' 05" | |
| 120 | 1° 12' | 4774.65 | 0° 43' 12" | .503 | 120.000 | .128 | 60.000 | 0° 14' 25" | |
| 130 | 1° 18' | 4407.37 | 0° 50' 42" | .640 | 129.999 | 1.162 | 65.000 | 0' 16' 55" | |
| 140 | 1° 24' | 4092.55 | 0° 58' 48" | .798 | 139.997 | .199 | 70.000 | 0' 19' 35" | |
| 150 | 1° 30' | 3819.72 | 1° 07' 30" | .982 | 149.995 | .246 | 75.000 | 0' 22' 30" | |
| 160 | 1° 36' | 3580.98 | 1° 16' 48" | 1.191 | 159.992 | .299 | 80.000 | 0' 25' 35" | |
| 170 | 1° 42' | 3370.34 | 1° 26' 42" | 1.429 | 169.989 | .359 | 85.000 | 0' 29' 00" | |
| 180 | 1° 48' | 3183.10 | 1° 37' 12" | 1.696 | 179.986 | .424 | 90.000 | 0' 32' 25" | |
| 190 | 1° 54' | 3015.51 | 1° 48' 18" | 1.995 | 189.981 | .499 | 95.000 | 0' 36' 05" | |
| 200 | 2° 00' | 2864.79 | 2° 00' 00" | 2.327 | 199.976 | .582 | 100.000 | 0' 40' 00" | 90° 23' 28" |
| 210 | 2° 06' | 2728.37 | 2° 12' 18" | 2.693 | 209.969 | .673 | 105.000 | 0' 44' 05" | 16° 16' 04" |
| 220 | 2° 12' | 2604.35 | 2° 25' 12" | 3.097 | 219.961 | .774 | 109.999 | 0' 48' 25" | 8° 49' 08" |
| 230 | 2° 18' | 2491.12 | 2° 38 42" | 3.539 | 229.951 | .886 | 114.999 | 0' 52' 50" | 6° 44' 01" |
| 240 | 2° 24' | 2387.32 | 2° 52' 48" | 4.021 | 239.939 | 1.006 | 119.999 | 0' 57' 35" | 5° 45' 00" |

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# Table of Spirals. Rate of Increase 1° in 100'

| L | Deg. | Radius | Δ. | X | Y | $X_0$ | $Y_0$ | D | $D_1$ |
|---|---|---|---|---|---|---|---|---|---|
| 250 | 2° 30' | 2291.83 | 3° 07' 30" | 4.545 | 249.926 | 1.135 | 124.996 | 1° 02' 30" | 5° 12' 00" |
| 260 | 2° 36' | 2203.68 | 3° 22' 48" | 5.112 | 259.909 | 1.277 | 129.997 | 1° 07' 35" | 4° 52' 04" |
| 270 | 2° 42' | 2122.07 | 3° 38' 42" | 5.725 | 269.891 | 1.433 | 134.994 | 1° 12' 50" | 4° 41' 01" |
| 280 | 2° 48' | 2046.27 | 3° 55' 12" | 6.385 | 279.869 | 1.598 | 139.980 | 1° 18' 35" | 4° 34' 15" |
| 290 | 2° 54' | 1975.72 | 4° 12' 18" | 7.094 | 289.844 | 1.776 | 144.975 | 1° 24' 05" | 4° 30' 53" |
| 300 | 3° 00' | 1909.86 | 4° 30' 00" | 7.853 | 299.815 | 1.965 | 149.969 | 1° 30' 00" | 4° 29' 54" |
| 310 | 3° 06' | 1848.25 | 4° 48' 18" | 8.665 | 309.782 | 2.170 | 154.964 | 1° 36' 10" | 4° 30' 52" |
| 320 | 3° 12' | 1790.49 | 5° 07' 12" | 9.531 | 319.745 | 2.387 | 159.959 | 1° 42' 40" | 4° 32' 56" |
| 330 | 3° 18' | 1736.23 | 5° 26' 42" | 10.453 | 329.702 | 2.619 | 164.955 | 1° 48' 55" | 4° 36' 27" |
| 340 | 3° 24' | 1685.17 | 5° 46' 48" | 11.432 | 339.654 | 2.863 | 169.944 | 1° 55' 40" | 4° 40' 04" |
| 350 | 3° 30' | 1637.02 | 6° 07' 30" | 12.471 | 349.600 | 3.120 | 174.933 | 2° 02' 34" | 4° 45' 54" |
| 360 | 3° 36' | 1591.27 | 6° 28' 48" | 13.571 | 359.540 | 3.406 | 179.924 | 2° 09' 40" | 4° 51' 46" |
| 370 | 3° 42' | 1548.53 | 6° 50' 42" | 14.733 | 369.472 | 3.707 | 184.915 | 2° 17' 20" | 4° 58' 02" |
| 380 | 3° 48' | 1507.79 | 7° 13' 12" | 15.960 | 379.397 | 4.060 | 189.899 | 2° 24' 20" | 5° 04' 50" |
| 390 | 3° 54' | 1469.12 | 7° 36' 18" | 17.253 | 389.313 | 4.380 | 194.886 | 2° 32' 15" | 5° 12' 24" |
| 400 | 4° 00' | 1432.39 | 8° 00' 00" | 18.615 | 399.220 | 4.673 | 199.870 | 2° 40' 10" | 5° 20' 16" |
| 410 | 4° 06' | 1397.45 | 8° 24' 18" | 20.046 | 409.118 | 5.037 | 204.854 | 2° 48' 20" | 5° 28' 30" |
| 420 | 4° 12' | 1364.18 | 8° 49' 12" | 21.549 | 419.005 | 5.417 | 209.834 | 2° 56' 40" | 5° 36' 44" |
| 430 | 4° 18' | 1332.44 | 9° 14' 42" | 23.125 | 428.881 | 5.816 | 214.802 | 3° 05' 10" | 5° 46' 08" |
| 440 | 4° 24' | 1302.18 | 9° 40' 48" | 24.777 | 438.744 | 6.236 | 219.787 | 3° 13' 55" | 5° 56' 30" |
| 450 | 4° 30' | 1273.24 | 10° 07' 30" | 26.505 | 448.605 | 6.676 | 224.756 | 3° 22' 50" | 6° 03' 46" |
| 460 | 4° 36' | 1245.56 | 10° 34' 48" | 28.311 | 458.432 | 7.136 | 229.735 | 3° 32' 00" | 6° 15' 06" |
| 470 | 4° 42' | 1219.06 | 11° 02' 42" | 30.198 | 468.254 | 7.617 | 234.704 | 3° 41' 25" | 6° 25' 22" |
| 480 | 4° 48' | 1193.66 | 11° 31' 12" | 32.167 | 478.060 | 8.121 | 239.673 | 3° 51' 00" | 6° 35' 58" |

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